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THE FREEZE-DRYING INDUSTRY: PROJECTIONS OF CAPITAL AND LABOR REQUIREMENTS
1963-70

By Kermit Bird

To some observers, freeze-drying appears on the threshold of becoming a major food preservation industry. To others, freeze-drying is scarcely to be reckoned as a food-preserving process. They consider it useful only in preserving biological and pharmaceutical supplies, and museum specimens. Equipment company personnel, food processors already in the freeze-drying business, and armed forces food research people are optimistic about the future of the industry. Food technicians and cost engineers tend to be cautious, and sometimes even pessimistic, concerning industry prospects.

My feeling is that freeze-drying is no longer a novel food preservation process. It is an important emerging dehydration technique in a growing family of food drying methods. Offering the advantage common to other dehydration technics--lightness in weight--there is no need for refrigeration. It differs from other drying methods in that its products retain flavor to a greater degree. Foods thus dried rehydrate faster and more completely. Processing costs are higher.

George Eliot said, "Ignorance gives one a large range of possibilities". This describes the general lack of economic knowledge surrounding freeze-drying. Processing costs are being quoted in the range of 2 to 30 cents per pound. Estimates of future industry volumes range from zero up to 2 billion pounds annually. Assessments of food quality run the scale from "first class" to "so what". There is no information on investment and labor needs of this unfolding industry. This paper is timely in that we shall examine the industry to gain a better perspective of its future. Particular attention is paid to investment and labor opportunities.

To have a good chance of success any new food processing technique needs to meet one or more of the following conditions: (1) Lower costs--this may mean lower marketing, processing, or production costs; (2) higher quality foods; (3) more convenient foods; or (4) special uses of the foods. 1/ Where do freeze-dried foods fit in with these four requirements? Certainly, these foods do not have lower costs. Regarding quality, they are generally poorer than frozen or canned foods, but superior to other dried foods. Since they are dried, a fairer comparison is to liken them to dehydrated rather than frozen or canned items. What about convenience? Compared with canned, they are generally less convenient. Compared with frozen, they may be less or more convenient, depending on the individual item. When compared with other dehydrated foods, they rehydrate faster and on this basis may be judged more convenient. In special-use characteristics, freeze-dried foods have their greatest application. Current usage of these foods by the armed forces, moun-

3 Prepared for presentation to the Philadelphia Chapter of the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Philadelphia, Pa., April 9, 1964.

1/ These four prerequisites for new food processing techniques were suggested by Dr. Robert Enochian, Western Utilization Research and Development Division, U. S. Department of Agriculture, Albany, California.

tain climbers, space flights, safaris into primitive regions, and for general camping show them outstanding for specialized functions. 2/ Undoubtedly, they will find many other specialized uses in remanufacturing and in the institutional and retail market places.

Volume predictions, used here as the basis of investment and labor estimates, depend on freeze-dried foods being high quality dried foods with specialized uses. Before we estimate future volumes of the food freeze-drying industry, we first examine the recent past and present. It is difficult to assess the future unless we recognize where we are and have been.

Background of the Industry

Commercial freeze-dried food items were introduced on the U. S. market about 1959. New ones have been forthcoming each year, so that a current count includes 50 to 60 different freeze-dried foods for sale. Total drying shelf area at the end of 1962 was about 13 thousand square feet (table 1). Drying shelf area is a commonly-used measure of capacity of a drying plant. There were about $6\frac{1}{2}$ million pounds of frozen food dried, and this resulted in 2 million pounds of dried end-product, and $4\frac{1}{2}$ million pounds of water evacuated. If the seven freeze-driers in business in 1962 had run at their full capacity, they could have dried 14 million pounds of frozen food. As it was, they operated at a level of 46 percent of capacity.

By 1963, four new freeze-drying plants had entered business. The 11-firm industry, in the latter part of that year, had about 22 thousand square feet of shelf area (table 1). Volume of frozen food dried was about 11.7 million pounds-- 8 million pounds of water evacuated and 3.7 million pounds of dried food. Capacity of the industry that year was about 26 million pounds of frozen food.

In comparing 1962 with 1963, number of plants increased 57 percent, shelf area expanded 70 percent, capacity increased 88 percent, and volume of food dried rose 80 percent. The industry expanded three ways: plants in business improved their efficiency, increased their capacity, and new firms entered business. The largest increase was due to new firms entering the market.

In the early months of 1964, two new plants will have started processing and several others are under construction. Of the 14 U. S. plants now in operation or under construction, 6 are on the West Coast, 4 are in the midwest, 3 are in the East, and 1 is in the South.

2/ A specialized use of freeze-dried foods is in our space program. In the 1963 Mercury project, freeze-dried chicken and gravy and freeze-dried pot roast were used for the first time in a space flight. Plans for the Gemini program include the following cooked freeze-dried meat dishes: (1) Chicken and gravy, (2) beef pot roast, (3) beef and gravy, (4) meat sauce and spaghetti, (5) beef and vegetable dish, (6) chicken and vegetable dish, (7) Canadian bacon and apple sauce, (8) sausage pattie and (9) veal and barbeque sauce (this latter one has not been completely tested). For vegetables there are (10) green beans with cream sauce, and (11) carrots with cream sauce. Fruits include (12) fruit cocktail, and (13) peaches. Salads include: (14) Tuna, (15) chicken, (16) salmon, (17) potato, and (18) shrimp cocktail. One pudding has a freeze-dried ingredient (19) apricots. All these items are to be rehydrated before using. The following items are not to be rehydrated except in the mouth. They are especially prepared to be crumble proof and are bite size. Sandwiches: (20) Peanut butter, (21) cheese, (22) beef, and (23) chicken. There is (24) plain toast and (25) cinnamon toast. Protein bites include: (26) Beef bite, (27) chicken bite, (28) egg and bacon omelet. Dessert bites include (29) strawberry, (30) apricot, and (31) pineapple.

Table 1--Estimated production of U. S. freeze-drying plants, 1962 and 1963

Firm 1/ 2/	Drying shelf area	Capacity operation throughout year 2/	Days plant operated	Drying Cycles per day	Frozen food per foot of shelf area	Food dried in year	Volume if operated at capacity
-----1962-----							
	Sq. feet	Percent	Days	Cycles	Pounds	1,000 Pounds	
A	2,500	36	90	2.0	2.4	1,080	3,000
B	2,400	80	200	2.3	2.4	2,650	3,312
C	2,000	50	125	2.0	2.3	1,150	2,300
D	2,000	50	125	1.8	2.0	900	1,800
E	1,800	12	30	1.5	2.5	202	1,688
F	1,200	40	100	2.0	2.2	440	1,100
G	1,000	8	20	2.0	2.0	80	1,000
Total 1962	12,900				6,502	14,200	
-----1963-----							
A	5,000	44	110	2.0	2.0	2,200	5,000
B	3,000	60	150	2.0	2.4	2,160	3,600
C	3,000	40	100	2.0	2.0	1,200	3,000
D	2,400	89	222	2.5	2.4	3,197	3,600
E	2,000	50	125	2.0	2.5	1,250	2,500
F	1,800	20	50	2.0	2.5	450	2,250
G	1,200	20	50	2.4	2.0	288	1,440
H	1,200	40	100	2.0	2.0	480	1,200
I	1,000	10	25	2.0	2.3	115	1,150
J	1,000	16	40	2.3	2.4	221	1,380
K	500	6	15	2.0	2.3	35	575
Total in 1963	22,100				11,586	25,695	

1/ Firm names are coded to protect their identity.

2/ Capacity is defined as operating 6,000 hours per year. Several plants listed were in operation less than a full year.

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The following questions outline discussion of the future of the industry.

- * By 1970, how large will the food freeze-drying industry be?
- * At what rate will it grow between now and then?
- * How much capital will be needed in this industry?
- * How much labor will be involved?
- * How will the food-processing industry be affected by freeze drying?

Anticipated Volumes

Estimates of freeze-drying production are calculated for each year from 1962 through 1970. Volume projections are based upon the limitations given in the assumptions section on the last page of this paper. 3/

The growth pattern of freeze-drying from 1962 with projections to 1970, is shown in Figure 1. This curve, typical of new industries, expands slowly at first, then gains tempo. 4/ By 1970, a volume of 250 million pounds of freeze-dried foods per year is expected. The total output of food freeze-drying is nonetheless small when compared with the U. S. food canning and freezing industries. 5/ One factor which should materially help the industry is the development of a continuous-flow drier. Several of these have been designed and I anticipate they will be used commercially by 1967. Another innovation that shows promise is introduction of newer heating methods, such as microwaves.

Investment in the Freeze-Drying Industry

Investment is calculated on the basis of cost per square foot of shelf area needed. Shelf needs of the industry were calculated using length of cycle, food loaded on the shelf area, and yearly operation. Shelf area of the industry will be about 200,000 square feet in 1970 (table 2).

3/ The freeze-dried food volumes for 1970 are estimated in Bird, Kermit, "Freeze-Drying of Foods: Cost Projections," MRR 639, Jan. 1964, 37 pages. See pages 26, 27, and 28. Briefly, the estimating process used was to list all foods having a potential freeze-drying volume. Then, the present processed volume of each of these foods was ascertained. Finally, a subjective freeze-drying percentage was applied to each food processing figure. As an example, it was believed that mushrooms would be an important freeze-dried food. Then, it was found that 115 million pounds of mushrooms are currently being processed and it was believed that seven percent of their processed volume would be freeze-dried in 1970. This equaled eight million pounds, and became a part of the total freeze-drying estimate. A similar estimating technique was used for all anticipated food items and food groups. Groupings included meats, seafoods, fruits, vegetables, berries, juices, mushrooms, dairy products, beverages, seasonings, desserts, miscellaneous foods, and new items not now marketed.

4/ The swift acceptance of frozen and dehydrated potato products in the period following their introduction provides an example of how rapidly a new industry may grow. Potatoes, frozen and dehydrated, were 210 million pounds in 1953, and increased to 970 million pounds by 1963. Estimated by National Potato Council, November 1963.

5/ U. S. volumes of canned and frozen food total over 27 billion pounds.

250 mil. lb.



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Then, with shelf area needs as a basis, investment was calculated using dollars per square foot of shelf area. Table 3 shows equipment requirements will increase from about \$1.4 million per year in 1963 to \$9.3 million per year in 1970. This is a 7-fold increase. If the industry develops as anticipated, there will also be a need for capital in packaging materials, storage space, shipping and transportation facilities, and product development. Although little information is available concerning associated investment effects within the food industry, there are associated investments required. As an example, 100 pounds of food freeze-dried per hour requires 11.8 tons of refrigeration. This is 1.8 tons for freezing the food and 10 tons for the refrigerated condensers in sublimating the moisture. From this, 12,250 tons of new refrigeration equipment, costing approximately \$17 million, may be needed by 1970. Other investment of like nature will be required, but their value is not estimated here.

Table 3--Food freeze-drying investment expectations, 1963-70

Year	: Cost of equipment :		Freeze-drying		:Investment:		Total
	New	:Rebuilding	equipment	investment	: in bldgs.:	new	investment
		: obsolete	New	:Renovation:	Total	:equipment	: per year
	Dollars/ sq. ft.		Million dollars				
1963	\$150	\$105	\$1.1	\$.3	\$1.4	\$.2	\$1.6
1964	140	98	1.0	.4	1.4	.2	1.6
1965	130	91	1.7	.5	2.2	.3	2.5
1966	125	88	1.7	.7	2.4	.3	2.8
1967	117	82	1.7	.9	2.6	.4	3.0
1968	110	77	3.7	1.1	4.8	.7	5.4
1969	105	74	4.8	1.5	5.8	.8	6.6
1970	100	70	6.2	2.0	8.2	1.1	9.3

Labor Needs in the Freeze-Drying Industry

Using volume projections and shelf area requirements, we now estimate the future size and number of freeze-drying plants. These estimates are then used to formulate labor requirements.

Projected number of plants in the industry increases from 11 in 1963 to 42 in 1970 (table 4). Plant sizes are larger in the latter years. As an example, in 1963 all food was dried in plants with less than 5,000 square feet of shelf area. In 1970, 80 percent of the food may be dried in plants larger than this.

Industry labor needs are derived using number of plants for each size category and the number of employees per plant from table 5. A small plant uses 5 to 9 employees, plus one salaried worker. A larger plant, similar to the 32 ton per day one, needs about 19-22 wage workers and two or three full-time salaried employees.

Table 4--Estimates of numbers and size of freeze-drying processing plants, 1962-70

	Square feet of drying shelf area per plant						Total	Total
Year	Less than 2,000	2,000 to 3,999	4,000 to 5,999	6,000 to 9,999	10,000 to 14,999	15,000 to 20,000	plants	drying shelf area of industry
	Number of Plants						1,000 sq. ft.	
1962	3	4	---	---	---	---	7	12.9
1963	6	5	---	---	---	---	11	22.1
1964	8	5	1	---	---	---	14	27.9
1965	10	7	2	---	---	---	19	41.0
1966	12	9	3	---	---	---	24	54.9
1967	13	11	4	1	---	---	29	69.6
1968	14	11	5	2	1	---	33	103.4
1969	14	11	7	3	2	1	38	144.0
1970	14	11	8	4	3	2	42	205.8

Table 5--Size of freeze-dry processing plant related to labor needs (synthetic data)

Capacity of plant	Full-time wage workers	Full-time salaried employees
Tons of water evacuated per day		
2	5 to 9	1.0
4	10 to 12	1.5
8	13 to 15	2.0
16	16 to 18	2.2
32	19 to 22	2.5

Number of employees directly involved in freeze-dry processing is estimated at 78 in 1962. There were 116 in 1963, and may be 693 by 1970, table 6. This is a 6-fold increase in the 9 year period. The less-than-proportionate increase in labor relative to volume and investment assumes plants will be more mechanized as the industry develops.

Other workers, indirectly involved, include those in food preparation, freezing, packaging, warehousing, and shipping. These may add 3,200 jobs. If product development; procurement of raw materials, containers, cases, and other supplies; transportation; and sales and promotion are included, another 3,100 jobs are estimated. Total new jobs in 1970 include: (1) Those in drying--about 700; (2) those involved in processing and preparation but not in drying--about 3,200; and (3) those involved with the finished product, raw materials, and containers--about 3,100. The newly-created jobs will not exert large demands on the national labor market although in individual locations a freeze-drying plant may be important.

Table 6--Anticipated number of employees in the freeze-dry processing industry
1962 to 1970

Year	:	Full-time production workers	:	Full-time salaried employees
1962	:	69	:	9
1963	:	102	:	14
1964	:	131	:	18
1965	:	184	:	25
1966	:	237	:	33
1967	:	286	:	40
1968	:	374	:	50
1969	:	475	:	62
1970	:	612	:	81

Summary

The 11 commercial freeze-drying plants in the United States have a drying shelf area of about 22 thousand square feet. They have a capacity of drying about 26 million pounds of frozen food, but in 1963, dried only 12 million pounds.

By 1970, the 42 plants in the freeze-drying industry may have an annual production of about 250 million pounds and a capacity for drying 400 million pounds.

Present annual rate of investment (1964) in the freeze-drying industry is estimated at about \$1.6 million. It may be \$9 million annually by 1970. Most will be for new equipment. In 1970, the industry will have a shelf area capacity of 206,000 square feet.

In 1970, about 700 full-time workers will man the drying operations. Another 6,300 workers will perform associated work--making a total of 7,000 persons engaged in the new-fledged industry.

Freeze-dried foods may displace certain frozen, canned or dried foods, where freeze-dried items fill a specific need; but will not seriously affect other food-processing methods.

Even though freeze-dried foods may be used as substitutes for other processed foods, they will have an expanding market--a new one.

In spite of the several advantages of freeze-dried foods, their volume is limited by high processing costs. Even though their palatability characteristics are better than most other dried foods, many items are still in need of flavor research. Freeze-dried foods are not now ready nor able to compete for a large-volume market, but they will be used successfully in special areas where their unique qualities give them a particular advantage.

Assumptions and Limitations

Projections are based on the following assumptions: (1) Changes in freeze-drying technology will continue to occur at about the same rate as in the past. Main ones expected for the future will be continuous flow driers. (2) The knotty problems involved in heat application and packaging will be largely overcome by 1967. Microwave heating methods will be in general use for the latter part of the drying cycle. (3) Technological improvements in other drying methods will be developed at about the same rate as in the past. (4) Prices of dried and other processed foods will remain at about the same absolute and relative levels as at present. (5) The trend of increasing consumptions of dried foods will continue. (6) An implied assumption is that volume of food freeze-dried can and will be marketed. (7) Continuation of world tension resulting in a high government demand for dried foods.

Some limitations and restrictions that pertain to equipment include: (1) Equipment used in freeze-drying will be obsolete five years from date of installation. Each existing plant will be modernized when five years old. Equipment salvaged and renovated is valued at 30 percent of its cost. (2) New type equipment will be developed with prices lower than at present. (3) Cycle length will decrease from 12 to 8 hours. Shelf loads will increase from an average of 2.3 to 2.7 pounds per square foot in the batch system plants.

This speech reprint is one in a USDA series on freeze-drying. Following is a listing of others on this subject:

Selected Writings on Freeze-Drying, ERS-147, Jan 1964, 53 pp. Contains previously published speeches and articles entitled:

Freeze-Drying Progress and Problems, F-D No. 1

Freeze-Drying Expectations, F-D No. 2

Freeze-Dried Poultry, F-D No. 3

Directory of Freeze-Drying, F-D No. 4

Forecast on A Food Processing Method--Freeze-Drying

Freeze-Dried Foods and the Frozen Food Industry

Implications of Freeze-Drying for Commodities Produced in Western U. S.

Freeze-Drying of Foods--A Look into the Future

Freeze-Drying of Foods: Cost Projections, MRR-639, Jan 1964, 34 pp

Freeze-Drying of Foods--A Look into the Future, ERS-134, Aug 1963, 7 pp

(Included in Selected Writings on Freeze-Drying, above)

Freeze-Dried Foods: Palatability Tests, MRR-617, July 1963, 36 pp

(Limit of one per person)

Freeze-Drying of Foods: A List of Selected References (an annotated bibliography) Lib. List 77, July 1963, 79 pp (Limit of one per person)

Freeze-Drying Citations (list of recent literature references) Feb 1964,

6 pp

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